

Impact of Gestational Diabetes Mellitus on Neonatal Birth Outcomes

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Abstract

Aims/Background The purpose of this study is to investigate the risk factors for gestational diabetes mellitus (GDM) during pregnancy and its impact on neonatal birth outcomes.

Methods A total of 2010 cases of mothers with GDM who underwent routine prenatal examinations and delivered at The Fourth Hospital of Shijiazhuang from June 2021 to April 2022, and their newborns were selected as the GDM group. For comparison, 2087 cases of mothers with normal glucose tolerance (NGT) and their newborns during the same period were selected as the NGT group. Birth outcomes of both groups were compared.

Results Pregnant women in the GDM group exhibited significantly higher proportions of advanced age, higher body mass index (BMI), and irregular dietary habits compared to the NGT group ($p < 0.05$). Conversely, the GDM group had significantly lower proportions of nutrient supplementation and prenatal exercise compared to the NGT group ($p < 0.05$). The incidences of macrosomia, neonatal hypoglycemia, hyperbilirubinemia, and acute respiratory distress syndrome (ARDS) were significantly higher in the GDM group compared to the NGT group ($p < 0.05$ for all). Among GDM women with adverse outcomes, significant differences were observed in pre-pregnancy BMI, insufficient or excessive weight gain during pregnancy, and poor glycemic control during pregnancy compared to those without adverse outcomes ($p < 0.05$ for all). Poor glycemic control during pregnancy, pre-pregnancy BMI, and inadequate or excessive weight gain were significant factors influencing adverse pregnancy outcomes in GDM patients ($p < 0.05$).

Conclusion The risk factors for GDM include advanced maternal age, being underweight, overweight, or obese prior to pregnancy, irregular eating habits, dietary nutritional deficiencies, and lack of prenatal exercise. The incidence of adverse pregnancy outcomes is higher in GDM patients compared to those without GDM. Poor glycemic control during pregnancy and higher pre-pregnancy BMI are significant factors that contribute to negative outcomes for both GDM patients and their newborns.

Key words: gestational diabetes mellitus; neonates; birth outcomes; body mass index; macrosomia; hypoglycemia

Submitted: 21 June 2024 Revised: 24 July 2024 Accepted: 2 August 2024

How to cite this article:

Liu Y, Wang M, Zhou J. Impact of Gestational Diabetes Mellitus on Neonatal Birth Outcomes: A Study in Shijiazhuang, China. *Br J Hosp Med.* 2024. <https://doi.org/10.12968/hmed.2024.0410>

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Introduction

Gestational diabetes mellitus (GDM) refers to varying degrees of abnormal glucose metabolism occurring during pregnancy, excluding pre-existing diabetes mellitus (DM) prior to pregnancy ([American Diabetes Association, 2019](#)). It usually occurs during the second or third trimester and has been increasing in prevalence over the years ([Mack and Tomich, 2017](#)). GDM is a common complication of pregnancy, posing significant risks to both the mother and the child ([Zhong et al, 2022](#)).

GDM increases the long-term risk of type II diabetes, metabolic syndrome, obesity, and other diseases for both the mother and the offspring (Okoth et al, 2020). The likelihood of women with GDM developing type II diabetes is 7 to 10 times higher than those without GDM (Sinha et al, 2023), making GDM an important predictor of future diabetes (Xun et al, 2021).

GDM is closely associated with adverse neonatal outcomes such as macrosomia, preterm birth, neonatal asphyxia, fetal growth restriction, neonatal hypoglycemia, hyperbilirubinemia, and acute respiratory distress syndrome (ARDS) (Vounzoulaki et al, 2020; Yap et al, 2022). It is also linked to increased risks of perinatal morbidity such as preeclampsia, cesarean deliveries, shoulder dystocia, and type II diabetes mellitus in the postpartum period (Mishra et al, 2021). GDM affects 16.7% of all pregnant women, and approximately 21.1 million babies are born to pregnant women with diabetes each year (Melekoglu and Celik, 2022). The risk of GDM among pregnant women varies according to different regions and dietary habits (Vounzoulaki et al, 2020; Yap et al, 2022). With changes in economic conditions and lifestyles, and the continuous increase in the proportion of underweight, overweight, or obese women, the incidence of GDM has been rising annually (Mak et al, 2019).

This study analyzed the newborns of GDM and normal glucose tolerance (NGT) pregnant women at The Fourth Hospital of Shijiazhuang, aiming to investigate the local risk factors of GDM and its relationship with newborn birth outcomes. This research can offer valuable new insights that are crucial for guiding antenatal care and early screening to identify high-risk groups for GDM, enabling timely interventions to reduce the incidence of GDM and improve neonatal birth outcomes.

Methods

Participants

A total of 4097 pregnant women who had regular prenatal examinations, follow-up, and hospitalization for delivery at The Fourth Hospital of Shijiazhuang from June 2021 to April 2022 were selected for this study. The Fourth Hospital of Shijiazhuang is the largest specialized hospital for obstetrics and gynecology in China, handling over 31,000 deliveries annually. The annual delivery volume accounts for more than two-thirds of the local deliveries, and the patients are pregnant women of all ages, most of whom live in the Shijiazhuang area. The age range of the participants was 20–47 years old. Clinical data of the participants' pre-pregnancy, pregnancy, and postpartum newborns were tracked and analyzed. According to the GDM diagnostic criteria, the pregnant women were divided into the GDM group (n = 2010) and the normal glucose tolerance (NGT) group (n = 2087). In this study, the occurrence of macrosomia, neonatal asphyxia, full-term small-for-gestational-age infants, neonatal hypoglycemia, hyperbilirubinemia, and acute respiratory distress syndrome (ARDS) were set as adverse pregnancy outcomes. In the GDM group, there were 520 cases of adverse pregnancy outcomes, while there were 1490 cases with no adverse pregnancy outcomes.

The inclusion criteria were as follows: (1) ability to complete the pregnancy questionnaire survey and sign the informed consent; (2) no pregnancy complications such as gestational hypertension; (3) complete maternal and child health care records; (4) no history of diabetes, hypertension, chronic liver disease, kidney disease, cardiovascular disease, or mental illness; (5) no history of long-term use of drugs that affect glucose metabolism (such as glucocorticoids or diuretics). Both groups consisted of full-term singleton infants without hemolytic disease, infection, birth injury, or other diseases, and both groups of mothers had no other pregnancy complications and no family history of diabetes.

Exclusion criteria: Pregnant women in both groups with a history of diabetes, hypertension, chronic liver disease, kidney disease, cardiovascular diseases, or a history of mental disorders were excluded. Additionally, those who were currently using medications that affect glucose metabolism, such as glucocorticoids or diuretics, were also excluded.

GDM Diagnostic Criteria

The diagnostic criteria for GDM in this study were based on the 2021 American Diabetes Association (ADA) guidelines ([American Diabetes Association, 2021](#)). A 75 g oral glucose tolerance test (OGTT) was conducted, and GDM was diagnosed if any of the following criteria were met: fasting blood glucose ≥ 5.1 mmol/L, 1-hour blood glucose ≥ 10.0 mmol/L, or 2-hour blood glucose ≥ 8.5 mmol/L. All eligible subjects underwent the OGTT between the 24th and 28th week of pregnancy. Test results were used to classify subjects into either the GDM group or the NGT group according to the criteria mentioned above. Pregnant women with fasting blood glucose levels ≥ 5.1 mmol/L in late pregnancy were also included in the GDM group. GDM women whose blood glucose remained above the diagnostic criteria after treatment were categorized as having poor blood glucose control.

Advanced Maternal Age

According to the 9th edition of *Obstetrics and Gynecology* published by People's Medical Publishing House, pregnant women aged 35 or older are classified as having advanced maternal age ([Xie et al, 2018](#)).

Weight Classification and Pregnancy Weight Gain Classification

According to the definition of pre-pregnancy body mass index (BMI) outlined in *Weight Monitoring and Evaluation During Pregnancy Period of Chinese Women* (National Health Commission of the People's Republic of China, 2022, <https://std.samr.gov.cn/hb/search/stdHBDetailed?id=E81118D5B776D734E05397BE0A0A0AF2>), weight categories are defined as follows: underweight (BMI < 18.5), normal weight ($18.5 \leq \text{BMI} < 24.0$), overweight ($24.0 \leq \text{BMI} < 28.0$), and obesity (BMI ≥ 28.0). A BMI between 18.5 and 24.0 is considered normal weight, while BMIs outside this range are classified as abnormal. Based on normal pre-pregnancy BMI, gestational weight gain is categorized into three groups: inadequate weight gain (<8 kg), adequate weight gain (8.0–14.0 kg), and excessive weight gain (>14 kg) (National Health Commission of the People's Republic of

China, 2022, <https://std.samr.gov.cn/hb/search/stdHBDetailed?id=E81118D5B776D734E05397BE0A0A0AF2>).

Collection of Clinical Records

(1) Maternal Data: This includes the collection of maternal age, medical history, gestational weight gain, pre-pregnancy BMI, dietary habits during pregnancy, prenatal exercise, and supplementation of micronutrients and vitamins.

(2) Neonatal Data: Assessment involves measuring newborns' birth weight (BW), birth weight index (WI), body length (BL), blood glucose, and bilirubin levels. Additionally, the presence of neonatal ARDS is determined.

(3) Neonatal Asphyxia: Defined as a 5-minute Apgar score of ≤ 7 , ineffective establishment of respiration, and an umbilical artery blood gas pH < 7.15 (Wang et al, 2018).

(4) Hypoglycemia: Blood glucose levels were measured using microsampling at 30 minutes and at 2, 6, 12, and 24 hours after birth. Hypoglycemia was defined as blood glucose < 2.2 mmol/L (Wang et al, 2018).

(5) Total Bilirubin Testing: Conducted through transcutaneous measurement of total bilirubin by collecting a heel blood sample (Wang et al, 2018).

Statistical Methods

Statistical analysis was performed using SPSS 26.0 (IBM Corp., Armonk, NY, USA). Count data were expressed as the number of cases and percentages (%), while measurement data were presented as the mean \pm standard deviation ($\bar{x} \pm s$). Normality tests assessed the distribution of measurement data. The chi-square test was used for count data, and the *t*-test was employed for measurement data. Fisher's exact test was applied for analyzing categorical variables with small sample sizes. Chi-square tests were used for univariate analysis, and logistic regression was used for multivariate analysis. A *p*-value of < 0.05 was considered statistically significant.

Results

General Information of Pregnant Women

The GDM group exhibited significantly higher proportions of advanced age, elevated BMI, and irregular dietary habits compared to the NGT group ($p < 0.05$). Conversely, the proportion of nutrient supplementation during pregnancy and adherence to prenatal exercise were significantly lower in the GDM group compared to the NGT group ($p < 0.05$) (Table 1).

Comparison of Clinical Data of Neonates in Two Groups

The GDM group had a gestational age range of 37–41 weeks and a birth weight range of 2080–5300 g, with 76 cases weighing less than 2500 g and 139 cases weighing more than 4000 g. The neonates' lengths in the GDM group ranged from 43 cm to 56 cm. The NGT group had a gestational age range of 37–41⁺⁶ weeks and a birth weight range of 2020–4730 g, with 63 cases weighing less than 2500 g and 104 cases weighing more than 4000 g. The neonates' lengths in the NGT group

Table 1. General information of NGT and GDM women.

Factor	NGT group, n = 2087	GDM group, n = 2010	t/χ^2	p -value
Age (years)	28.83 ± 3.73	29.91 ± 4.07	8.82	0.00
Pregestational BMI	22.20 ± 3.38	23.65 ± 4.08	12.42	0.00
Irregular diet (cases)				
Yes	249 (11.93%)	347 (17.26%)	23.42	0.00
No	1838 (88.07%)	1663 (82.74%)		
Pregnancy nutrients (cases)				
Yes	1722 (82.51%)	1546 (76.92%)	19.86	0.00
No	365 (17.39%)	464 (23.08%)		
Maternity exercise (cases)				
Yes	765 (36.66%)	405 (20.15%)	136.73	0.00
No	1322 (63.34%)	1605 (79.85%)		

NGT, normal glucose tolerance; GDM, gestational diabetes mellitus; BMI, body mass index.

Table 2. General information of NGT and GDM mothers.

Group	Sex (n/%)		Gestational age (w)	Birth weight (g)	Body length (cm)
	Male	Female			
GDM	1023 (50.90%)	987 (49.10%)	39.20 ± 1.00	3344.45 ± 439.47	50.26 ± 1.08
NGT	1056 (50.6%)	1031 (49.4%)	39.25 ± 1.08	3289.46 ± 416.73	50.25 ± 0.99
t/χ^2	0.04		-1.73	4.11	0.33
p -value	0.85		0.08	0.00	0.75

ranged from 42 cm to 56 cm. Birth weight in the GDM group was significantly higher than in the NGT group ($p < 0.05$). There were no statistically significant differences in gender ratios, gestational age, or body length between the two groups ($p > 0.05$) (Table 2).

Comparison of Neonatal Birth Outcomes in Two Groups

In the GDM group, there were 76 cases of small for gestational age (SGA) and 139 cases of macrosomia. Two cases had Apgar scores of ≤ 7 (asphyxia). Hypoglycemia occurred in 213 cases and was detected within 0.5 hours after birth. Hyperbilirubinemia occurred in 201 cases, and 15 cases had ARDS, with one case complicated by arothorax. In the NGT group, there were 57 cases of SGA, 104 cases of macrosomia, one case with an Apgar score of ≤ 7 , 42 cases of hypoglycemia, 165 cases of hyperbilirubinemia, and four cases of ARDS. The GDM group had significantly higher incidences of macrosomia ($p < 0.05$), neonatal hypoglycemia ($p < 0.05$), hyperbilirubinemia ($p < 0.05$), and ARDS ($p < 0.05$) compared to the NGT group. Although the rates of asphyxia and full-term SGA infants were slightly higher in the GDM group, these differences were not statistically significant ($p > 0.05$) (Table 3).

Table 3. Comparison of neonatal birth outcomes.

Group	SGA	Macrosomia	Asphyxia	Hypoglycemia	Hyperbilirubinemia	ARDS
GDM group (2010 cases)	76 (3.78%)	139 (6.92%)	2 (0.10%)	213 (10.60%)	201 (10.00%)	15 (0.75%)
NGT group (2087 cases)	57 (2.73%)	104 (4.98%)	1 (0.05%)	42 (2.01%)	165 (7.91%)	4 (0.19%)
χ^2	3.59	6.85	N/A	129.28	5.52	N/A
<i>p</i> -value	0.06	0.01	1.00	0.00	0.02	0.01

Note: the *p*-value for Asphyxia and ARDS are generated through Fisher's exact test. SGA, small for gestational age; ARDS, acute respiratory distress syndrome; N/A, not applicable.

Table 4. Comparison between GDM women with and without adverse pregnancy outcomes.

Factor	Adverse prognosis subgroup of GDM (520 cases)	GDM non-adverse prognosis subgroup (1490 cases)	<i>t</i> / χ^2	<i>p</i> -value
Age <35	454 (26.18%)	1280 (73.82%)	0.64	0.42
Age \geq 35	66 (23.91%)	210 (76.09%)		
BMI				
Pregestational BMI	24.00 \pm 4.29	23.53 \pm 4.00	2.26	0.02
Normal weight (18.5 \leq BMI < 24.0)	242 (21.68%)	874 (78.32%)	22.93	0.00
Abnormal weight (BMI <18.5 or BMI \geq 24.0)	278 (31.10%)	616 (68.90%)		
Weight gain				
Adequate weight gain	156 (19.95%)	626 (80.05%)	23.41	0.00
Inadequate or excessive weight gain	364 (29.64%)	864 (70.36%)		
History of spontaneous abortion				
Yes	86 (23.96%)	273 (76.04%)	0.84	0.36
No	434 (26.29%)	1217 (73.71%)		
Poor blood glucose control				
Yes	74 (36.27%)	130 (63.73%)	12.81	0.00
No	446 (24.70%)	1360 (75.30%)		

Table 5. Results of logistic regression.

	β	Standard error	Wald χ^2	z	p-value	95% CI	
Intercept	-0.38	0.24	2.39	-1.55	0.12	-0.86	0.10
Age (≥ 35 years)	-0.11	0.16	0.52	-0.72	0.47	-0.42	0.19
History of spontaneous abortion	-0.15	0.14	1.07	-1.03	0.30	-0.42	0.13
Poor blood glucose control	0.58	0.16	13.15	3.63	0.00	0.27	0.90
Normal weight ($18.5 \leq \text{BMI} < 24.0$)	-0.46	0.21	5.00	-2.24	0.03	-0.87	-0.06
Overweight ($24.0 \leq \text{BMI} < 28.0$)	-0.22	0.22	1.00	-1.00	0.32	-0.64	0.21
Obesity ($\text{BMI} \geq 28.0$)	0.03	0.24	0.02	0.13	0.90	-0.43	0.49
Adequate weight gain (8.0–14.0 kg)	-0.77	0.16	22.63	-4.76	0.00	-1.09	-0.45
Excessive weight gain (> 14 kg)	-0.27	0.16	2.97	-1.72	0.09	-0.58	0.04

Note: Dummy variables were created to analyse the influence of BMI and weight gain. For BMI, dummy variable (BMI) = 0 when BMI < 18.5 . For BMI, dummy variable (BMI) = 0 when BMI < 18.5 . CI, confidence interval.

Comparison between GDM Women with and without Adverse Pregnancy Outcomes

There were 520 cases of GDM women with adverse outcomes and 1490 cases without adverse birth outcomes. The GDM women with adverse outcomes had significantly different pre-pregnancy BMI ($p < 0.05$), weight ($p < 0.05$), insufficient or excessive weight gain during pregnancy ($p < 0.05$), and poor glycemic control during pregnancy ($p < 0.05$) compared to those without adverse birth outcomes. However, no significant differences were found in terms of age ($p > 0.05$) and history of miscarriage ($p > 0.05$) (Table 4).

Multivariable Logistic Regression Analysis of Factors Influencing Adverse Maternal and Neonatal Outcomes in GDM Patients

Multivariable logistic regression analysis was performed with the occurrence of adverse pregnancy outcomes as the dependent variable. The results indicated that poor glycemic control during pregnancy, abnormal pre-pregnancy BMI, and inadequate or excessive weight gain were significant factors influencing adverse pregnancy outcomes in GDM patients ($p < 0.05$) (Table 5).

As shown above, the coefficient for “Poor Blood Glucose Control” is positive, while the coefficients for “Normal Weight” and “Adequate Weight Gain” are negative. This indicates that poor blood glucose control during pregnancy is associated with an increased likelihood of adverse pregnancy outcomes. Conversely, maintaining a normal pre-pregnancy BMI and achieving adequate weight gain during pregnancy is associated with a reduced risk of adverse pregnancy outcomes.

Discussion

With the general improvement in living standards, dietary habits have undergone significant changes. Combined with the increasing prevalence of screening for GDM, the incidence of GDM has been rising annually (Dessi et al, 2022; Liu et al, 2022; Yong et al, 2018). In recent years, China’s policy allowing couples to

have a second or third child has led to an increase in older pregnant women, resulting in a significant rise in both the incidence and recurrence rate of GDM during subsequent pregnancies (Cheng, 2020; Zhu et al, 2022). Timely identification of GDM risk factors is crucial for reducing its incidence.

This study found that the occurrence of GDM at The Fourth Hospital of Shijiazhuang is associated with maternal age at conception, pre-pregnancy BMI, irregular dietary habits, nutrient supplementation, and adherence to exercise, which aligns with existing research findings (Li and Xu, 2015). Advanced maternal age is widely recognized as a major risk factor for GDM. It is generally believed that older individuals experience decreased insulin receptor sensitivity and affinity, and pregnancy itself promotes the development of diabetes. As age increases, the incidence of GDM also rises, with a notable increase in occurrence among pregnant women aged 30 and above. This study shows that the GDM group had a higher pre-pregnancy BMI compared to the NGT group, indicating that overweight and obese pregnant women are at a greater risk of developing GDM. Obesity is associated with increased insulin resistance and glucose intolerance, insensitivity of fat cells to insulin, excessive insulin secretion leading to insulin downregulation, elevated blood glucose levels, and reduced pancreatic islet cell function, thereby increasing the risk of diabetes development (Hu et al, 2022).

Additionally, this study found that supplementing vitamins and trace elements during pregnancy and maintaining prenatal exercise resulted in a lower incidence of GDM compared to the NGT group. This effect may be due to improved insulin resistance resulting from these interventions. The study also reported a significantly higher incidence of macrosomia, full-term small-for-gestational-age (SGA) infants, neonatal hypoglycemia, hyperbilirubinemia, and ARDS in the GDM group. These outcomes are related to changes in the intrauterine environment affecting fetal development. Alterations in cytokines secreted by the placenta lead to imbalanced fetal growth and development. This imbalance manifests as increased fetal weight and accelerated fetal growth, resulting in macrosomia when stimulated by the mother's hyperglycemic environment during pregnancy. High blood glucose levels in early pregnancy inhibit embryonic development, leading to delayed growth. Additionally, abnormal placental blood vessels, which are often observed, impact fetal development and can result in intrauterine growth restriction (IUGR), leading to the occurrence of full-term SGA infants (Luo and Qi, 2016).

This study also found that newborns delivered by mothers with GDM are more likely to develop ARDS. This is associated with fetal hyperinsulinemia, which antagonizes adrenal corticosteroids and inhibits the synthesis of fetal lung surfactant phosphatidylcholine, thereby delaying fetal lung maturity. Although fetal hyperinsulinemia promotes metabolic increases, it also raises oxygen consumption, exacerbating chronic fetal hypoxia and acidosis, which can lead to ARDS. Additionally, a higher incidence of hypoglycemia was observed in newborns delivered by mothers with GDM. The exposure to high maternal blood glucose levels followed by a sudden departure from this hyperglycemic environment at birth results in rapid glucose utilization due to the newborn's elevated insulin levels, leading to neonatal hypoglycemia. Some data suggest that the incidence of hypoglycemia in newborns

of GDM mothers can range from 30% to 50% (Lee et al, 2007). While neonatal hypoglycemia is often asymptomatic or transient, prolonged hypoglycemia can cause permanent central nervous system damage, impacting intellectual and motor development. Therefore, early feeding with glucose solutions, initiating breastfeeding, and closely monitoring blood glucose levels in newborns of GDM mothers are crucial for the prompt identification of hypoglycemia.

In our research, we also observed a higher incidence of abnormal bilirubin elevation in newborns delivered by mothers with GDM. This is due to chronic hypoxia experienced by GDM mothers, which increases extramedullary hematopoiesis in the fetus, leading to elevated nucleated red blood cells in fetal circulation. After birth, the rapid breakdown of these excess nucleated red blood cells results in hyperbilirubinemia. In severe cases, this can cause kernicterus, leading to neonatal death or long-term sequelae such as intellectual impairment, hypotonia, and hearing loss.

This study compared delivery outcomes of newborns born to mothers with GDM and found that those with adverse perinatal outcomes had significantly higher pre-pregnancy BMI and maternal blood glucose levels during pregnancy compared to those without adverse outcomes. This suggests that controlling blood glucose levels and managing pre-pregnancy BMI can improve perinatal outcomes for newborns. While previous research has identified advanced maternal age and a history of natural miscarriage as risk factors for GDM (Song et al, 2023), this study did not find these factors to be associated with adverse perinatal outcomes in newborns delivered by mothers with GDM.

The study examined factors influencing adverse maternal and neonatal outcomes in patients with GDM. It identified pre-gestational BMI, inadequate or excessive weight gain, and poor blood glucose control during pregnancy as significant factors associated with adverse outcomes. These findings suggest that GDM patients with higher pre-gestational BMI, excessive gestational weight gain, or inadequate blood glucose control are more likely to experience unfavorable outcomes for both mother and newborn. This underscores the importance of early identification and management of GDM, with a focus on glycemic control, pre-pregnancy BMI, and appropriate weight gain during pregnancy. Improving blood glucose control, maintaining a healthy pre-pregnancy BMI, and achieving appropriate weight gain can potentially reduce the risk of adverse outcomes in GDM patients. These results have clinical implications for healthcare providers, highlighting the need for comprehensive monitoring and interventions targeting these modifiable risk factors. The study primarily involved subjects from Shijiazhuang, and the conclusions may be influenced by local environmental and economic factors. Future research will aim to expand the geographical diversity of the cases and include a larger patient population to enhance the generalizability of the findings.

Conclusion

Effective management of GDM through glycemic control, maintaining a healthy pre-pregnancy BMI, and achieving appropriate weight gain during pregnancy significantly improves neonatal birth outcomes.

Key Points

- GDM was associated with old maternal age, higher pre-pregnancy BMI, and irregular dietary habits, alongside lower rates of nutrient supplementation and pregnancy exercise compared to the NGT group.
- Higher incidences of adverse outcomes such as macrosomia, neonatal hypoglycemia, hyperbilirubinemia, and ARDS were observed in the GDM group.
- Poor glycemic control, abnormal pre-pregnancy BMI, and inappropriate weight gain during pregnancy were key factors contributing to adverse outcomes in GDM patients.

Availability of Data and Materials

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

YL, MW and JZ designed the research study. YL and MW performed the research. JZ analyzed the data. YL drafted the manuscript. YL and MW contributed equally to the work. All authors contributed to important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the ethical regulations of the Declaration of Helsinki. This study was approved by the Ethics Committee of The Fourth Hospital of Shijiazhuang. The approval number is 20190006. All patients signed the informed consent form.

Acknowledgement

The authors thank the members of The Fourth Hospital of Shijiazhuang and The First Hospital of Hebei Medical University for helpful discussions.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

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